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Mineral water discharges at the Azores archipelago (Portugal): hydrogeological setting, chemical composition and mapping

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The geological setting of the Azores archipelago, located in the North Atlantic ocean, about 1500 km form Portugal mainland and made of 9 islands of volcanic origin, enhances the multiplicity of surface hydrothermal manifestations. Therefore, a field survey made possible to identify 101 mineral water discharges in the Azores, mainly of CO_2-rich cold waters and thermal waters, spread along São Miguel (75%), Terceira (6%), Graciosa (7%), Pico (2%), Faial (3%), São Jorge (5%) and Flores (2%) islands, as well as fumarolic grounds. Furnas and Fogo central volcanoes, two of the three composite active volcanoes that dominates the geology of São Miguel, the largest island of the archipelago, represent respectively about 41% and 24% of the discharges from the Azores.

Discharges are mainly from fissured aquifers, made of basaltic or trachitic lava flows. Instead, discharges from porous aquifers, made of pyroclastic deposits, mainly of pumice type, are less common, and are more frequent at São Miguel island.

The studied discharges correspond mainly to springs (75), and also to boiling pools (10), at fumarolic grounds, 14 drilled wells and 2 large-diameter wells. The boiling pools are only observable at São Miguel island, while drilled wells were made at São Miguel, Terceira and Graciosa.

Groundwater at Azores occurs in two major aquifers systems: (1) the basal aquifer system, which corresponds to fresh-water lenses floating on underlying salt water, and (2) in perched-water bodies. The basal aquifer system is in the coastal area, presenting generally a very low hydraulic gradient. From the 14 drilled wells only two are in perched-water bodies. Considering mineral springs, the majority discharge from perched-water bodies (77%), while all the boiling pools also discharge in altitude, also from perched –water bodies.

During the field survey an extensive campaign of sample collection was made in all islands, in order to characterize the chemical composition of these waters, which presents a large range of water types and mineralization magnitude. Several groups of waters are defined: (1) Na-HCO_3 and Na-HCO_3-Cl type waters, to which almost all the thermal and CO_2-rich waters belong, (2) Na-Cl type waters, to which discharges from the basal aquifer system belong and (3) acid-SO_4 type waters, to which some of the boiling waters of São Miguel island belong. A few samples show intermediate facies between these main water types.

The pH range between 2.2 and 7.82, discharge temperature between 15ºC and 99.5ºC (median=35ºC), and conductivity varies between 139 and 43100 μS/cm (median=906 μS/cm).

The main hydrogeochemical processes are the CO_2-dominated volatile absorption, water-rock interaction and mixture with hydrothermal fluids. Sulfate dominated composition is explained by the influence of steam heating, and the Na-Cl water type result from mixture with sea salts.

For the purpose of mapping mineral water discharges at the Azores a geochemical atlas was made using ESRI ArcGis 9.1 software. Data was divided in classes according to quartile values and spatial analysis was made through thematic mapping, for several features, as hydrogeological setting, water types and variables as discharge temperature, pH, conductivity, free CO_2 and major elements content. In the present contribution several examples of the hydrogeological maps are shown.